# HAWAII PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 43*

Fifth Progress Report
1 April 2002 through 30 June 2002

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Hydrology Laboratory

Office of Hydrologic Development
U.S. National Weather Service
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DISCLAIMER

The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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## 1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for Hawaii. Current precipitation frequency estimates for Hawaii are contained in *Technical Paper No. 43,* "Rainfall-Frequency Atlas of the Hawaiian Islands for Areas to 200 Square Miles, Durations to 24 Hours, and Return Periods from 1 to 100 Years" (U.S. Weather Bureau 1962). The update includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the study area and use accepted statistical methods. The study results will be published as a Volume of NOAA Atlas 14 on the internet using web pages with the ability to download digital files.

The study area covers the Hawaiian islands including Hawaii, Maui, Lanai, Molokai, Oahu, and Kauai. The study area including preliminary regions is shown in Figure 1.

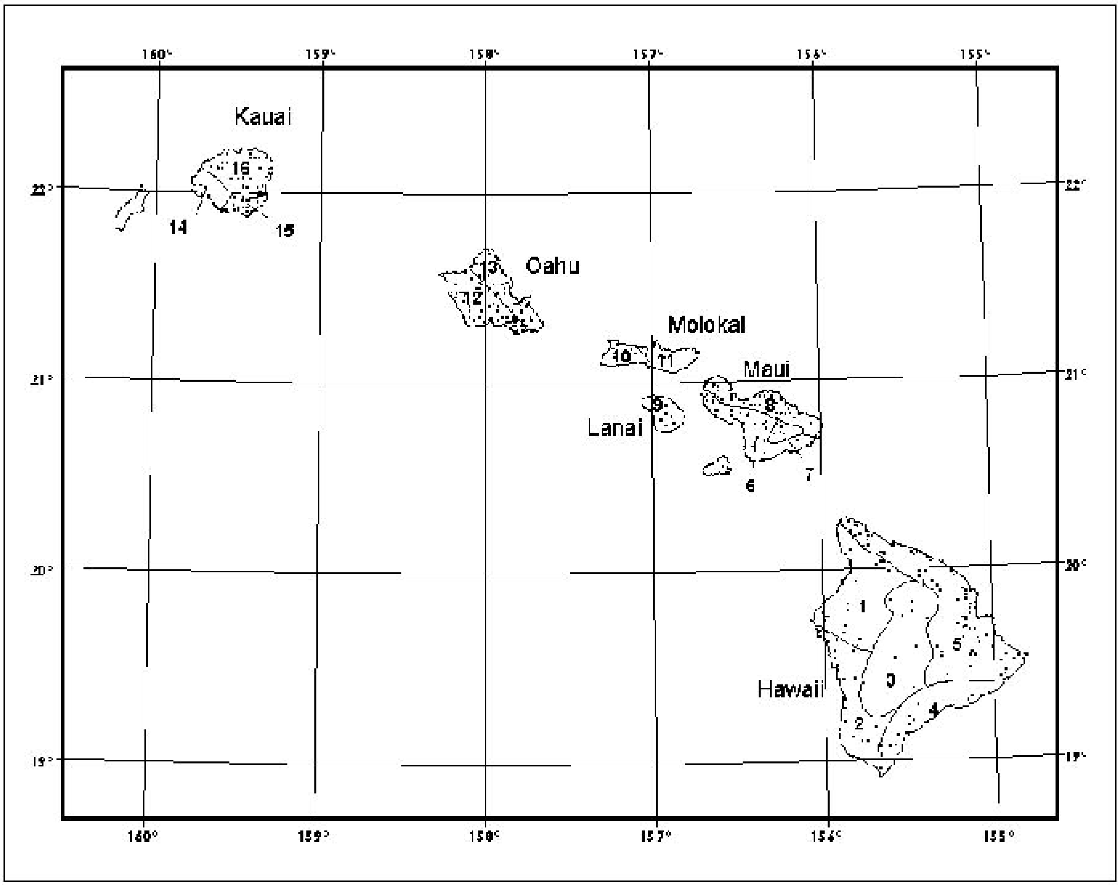


Figure 1. Hawaii Precipitation Frequency study area, regional divisions and daily station locations.

## 2. Highlights.

Data entry of monthly maximums from daily gages maintained by the State continues by the University of Hawaii. Entry started with the Big Island. Additional information on this subject is available in Section 4.1.

Several changes were made to the Precipitation Frequency Data Server (PFDS). Most important was the added function for selecting, either via a map or a list, an observing site. This function will allow for review of the point-precipitation frequency estimates before the interpolated grids are finalized. Additional information is provided in Section 4.2, Precipitation Frequency Data Server.

Software was developed to calculate the confidence intervals for all precipitation frequency estimates. Software was also developed to check the internal consistency of estimates and confidence intervals across durations. Additional information is provided in Section 4.3, Software Development.

Development of depth-area-duration (DAD) reduction relationships for areas from 10 to 400 square miles continues. Data has been gathered and quality controlled for 8 dense-area-drainage networks. Software development has begun. Additional information is provided in Section 4.4, Spatial Relations (Depth Area Duration Study).

Decisions have been made to exclusively publish the study results electronically to avoid printing expenses, and to publish monthly patterns of extreme precipitation but not compute monthly frequency estimates. Additional information is provided in Section 5, Issues.

## 3. Status.

### 3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percentage completed per task. Past status reports should also be referenced for additional information.

**Hawaii study checklist [estimated percent complete]:**

Data Collection, Formatting and Quality Control [25%]:

- Multi-Day
- Daily
- Hourly
- 15-minute
- N-minute

The University of Hawaii will continue digitizing daily data from a network of state operated gauges. Once this data is added to our data set the number of daily stations will greatly increase. The University will enter monthly maximums of daily data. Data from the Big Island will be entered first and subsequently provided to the HDSC to begin final QC and processing. Data entry by the University will then concurrently continue westward up the island chain as the HDSC processes data from the Big Island.

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 years [0%]:

- Multi-Day
- Daily
- Hourly
- 15-minute
- N-minute

Temporal Distributions of Extreme Rainfall [0%]

- Assemble hourly data by quartile of greatest precipitation amount and convert to cumulative rainfall amounts for each region
- Sort, average and plot time distributions of hourly maximum and median events by storm area, quartile and duration

Peer Reviews [0%]:

- Lead review of point precipitation frequency estimates

- Lead review of spatial interpolation grids

Data Trend Analysis [0%]

- Analyze linear trends in annual maxima and variance over time
- Analyze shift in means of annual maxima between two time periods (i.e., test the equality of 2 population distribution means)
-

Spatial Interpolation [0%]

- Create grids of interpolated means for each duration using PRISM
- Subject grids of interpolated means to external review

Precipitation Frequency Maps [0%]

- Create smoothed regional growth factor (RGF) grids using GRASS
- Multiply appropriate RGF and distributed mean grids to produce precipitation frequency grids for the durations of 5-min, 10-min, 15-min, 30-min, 1-hr, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day and 60-day at the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, 200-yr, 500-yr and 1000-yr return frequencies for a total of 162 maps
- Apply study-wide conversion factor to the 1-hour precipitation frequency grids to calculate the n-minute (5-, 10-, 15-, and 30-minute) grids
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

Deliverables [20%]

- Prepare data and documentation for web delivery

Several changes were made to the Precipitation Frequency Data Server (PFDS). Most important was the added function for selecting an observing site. This allows review of the point-precipitation frequency estimates before the interpolated grids are finalized.

Additional Work:

Spatial Relations (Depth Area Duration Study) [20%]

- Obtain data from dense-area reporting networks
- QC and format data from dense networks
- Compute maximum and average annual areal depth for each duration from stations from each network
- Compute ratio of maximum to average depth for all durations and networks and plot

- Prepare curves of best fit (depth area curves) for each duration and network

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in separate volume of NOAA Atlas 14.

## 4. Progress in this Reporting Period.

### 4.1 Data Collection and Quality Control.

A complete listing of State rainfall records for Hawaii County (The Big Island) has been completed by the University of Hawaii. For each station, the state key number, latitude, longitude, elevation, observer's name, and record length has been compiled. Out of a total of 400+ state stations, 136 have data of 20 years or longer. These stations contain data from 1955 onward. There are additional stations discovered on the Big Island with data dated from 1948. There were two extreme rain events noted with more than 10 inches of rainfall within 24 hours which occurred during the 1948-54 period. Because there were interesting storm events between 1948 and 1955 and adding these seven years would yield more gages with more than 20 years of data, the consensus is that the data base should be extended back to 1948.

HDSC received the daily data set, TD3206 from the National Climate Data Center for the Hawaiian Islands. This digital data set contains data from before 1949. We will update our database with the latest National Climate Data Center data when hand entry of the state data has been completed by the University of Hawaii.

### 4.2 Precipitation Frequency Data Server.

Several changes were made to the Precipitation Frequency Data Server (PFDS) this quarter. A function to extract data for a specific observing site was added. A user can now select an observing site from a pull-down list or by clicking on it from a map. In order to accommodate the observing site selection option, the PFDS interface changed slightly, as did the output page. Other changes include, but are not limited to: output duration changed from 10-days to 60-days, return periods were extended to 1000-years, reference maps were added to the output page to show the surrounding area, the seasonality option was removed, a link to the National Climatic Data Center showing nearby observing sites and sources of climate data was included, and a color-shaded elevation background was added to the clickable state maps.

### 4.3 Software Development.

Software was developed to calculate the confidence intervals associated with each precipitation frequency estimate at all durations (1-hour through 10-day). These intervals will be provided as an upper bound and a lower bound at the 90% confidence level.

Software was written to provide internal consistency to the precipitation frequency estimates across durations. Cases where a shorter duration has an estimate that is higher than the next longer duration (e.g., 2-hr = 1.9 and 3-hr = 1.5) will be identified. These inconsistencies are not realistic but are an artifact of the data analysis. The calculation of precipitation frequency estimates uses the mean annual maximum and the L-skewness of the data. Inconsistencies result when durations have similar means but the shorter duration has higher skewness. Practical adjustments using ratios with the previous durations will be made where appropriate to mitigate such inconsistencies. This type of adjustment will also be made for inconsistencies in confidence intervals.

Some stations included in the Study may have multiple missing years. Large gaps (i.e., sequential missing years) in an annual maxima series cause concern about the data series consistency. Using newly developed software, we will screen all data records for large gaps using specific "Gap Check" criteria before data are used for L-moment analysis. The criteria are:

1. Size criteria: Software will delete a beginning short data segment and gap segment if the data years of the short segment and the gap size meet one of the following conditions (and only if it also meets the subsequent criteria as well):

| **data years size** | **gap size** |
|---|---|
| 1 yr | 10 yrs |
| 2 yrs | 15 yrs |
| 3 yrs | 18 yrs |
| 4 yrs | 20 yrs |
| 5 - 10 yrs | >30 yrs |
| 10 - 15 yrs | >40 yrs |
| 15 yrs | >50 yrs |

2. High value criteria: If one of the highest annual maximum values for that station occurs in the short data segment, the software will not delete that segment but copy that station's annual maximum series to a log file that will be manually checked.

3. 20 year criteria: The software will not delete data segments if it leaves less than 20 years of data for that station, but will copy that station's annual maximum series to the log file.

4. Middle or end gap criteria: Stations with large gaps in the middle or towards the end of their record will be copied to the log file. Large gaps are defined as 10 years or more.

5. Sporadic gap criteria: If there are two or more sequential gaps of 5 or more missing years separated by 5 or less years of data at a station, then the annual maximum series will be copied to the log file.

Station records with gaps will be flagged by the software and examined on a case by case basis using an approach which preserves as much of the data as possible. Nearby stations will be inspected for concurrent data years to fill in the gap if they pass the statistical test for consistency. Latitude, longitude and elevation will be taken into account when examining nearby stations. Also, if there are sufficient years in each data segment, a t-test will be conducted on the two segments to assess the statistical integrity of the data record. To produce more congruent data records for analysis, station record length could be occasionally adjusted.

4.4 Spatial Relations (Depth Area Duration Study).

During the second quarter of 2002, processing of data continued for study areas being used to develop depth-area-duration (DAD) relationships applicable to basins ranging in area size from 10 to 400 square miles. Currently, 12 study areas are being considered (See Table 2). The areas were selected based on the following criteria: 1) Availability of a dense area of hourly reporting rain gauges; 2) location, as there is a desire to include as many geographically and orographically diverse study areas of the US as possible; and 3) minimum period of record for reporting gauges (at least 15 years of record). During the next quarter we will also examine potential networks for the Hawaiian Islands.

Data has been collected and prepared as shown in Table 2. Also, if additional dense-area-networks are identified, they will be added after the current software development phase of the projected is completed.

Table 2. Dense Area Rain Gauge Networks in DAD Study

| Depth Area Duration Study Areas | Data Processed |
|---|---|
| Walnut Gulch, AZ | T |
| Reynolds Creek,ID | T |
| Tifton, GA | T |
| Hastings, NE | T |
| Alamogordo Creek, NM | |
| Safford, AZ | |
| Santa Rita, AZ | |
| Cochocton, OH | T |
| Danville, VT | T |
| Chicago, IL (NCDC stations) | T |
| Riesel, TX | T |

4.5 Temporal Distribution.

Our methodology for developing temporal distributions of extreme rainfall events has been researched and verified. Our method is based on an Illinois State Water Survey Report (Huff, 1990) and determines the maximum and median precipitation event time distributions for 12, 24 and 72 hour duration events.

## 5. Issues.

### 5.1 Seasonality.

We reviewed the meaning, utility and computational difficulties associated with frequency estimates computed by season. Because of the noise in the data, seasonal estimates do not combine to give annual estimates. This incongruity cannot be resolved without arbitrary limits being placed on results. We are uncomfortable with imposing arbitrary limits but at the same time are concerned about the confusion that may be caused by publishing incongruous results. Furthermore, after checking with a variety of partners we found no consensus of demand for the estimates nor a consensus on how such results would be used. Accordingly we have decided not to prepare seasonal frequency estimates.

### 5.2 Publication.

Printing of the final documents is expensive and time consuming. Furthermore, we have found no reasonable way to avoid ongoing infrastructure costs of delivering and billing for the printed documents. Accordingly, we have decided to avoid both the costs and delay by publishing the documents in PDF format on the Internet.

## 6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section. The University of Hawaii Digitizing completion date is indicated as Month Zero ($M_0$).

Data Collection and Quality Control [$M_0$ + 3 months]
Trend Analysis [$M_0$ + 4 months]
L-Moment Analysis/Frequency Distribution [$M_0$ + 5 months]
Peer Review of Point Estimates [$M_0$ + 7 months]
Temporal Distributions of Extreme Rainfall [$M_0$ + 8 months]
Spatial Interpolation [$M_0$ + 10 months]
Precipitation Frequency Maps [$M_0$ + 11 months]
Web Publication [$M_0$ + 11 months]
Spatial Relations (Depth Area Duration Studies) [January 2003]

### 6.1 Data Collection and Quality Control.

An agreement has been established between the HDSC and the other funding agencies to wait for the University of Hawaii to manually digitize daily rainfall data from a network of state maintained rain gauges. The University estimates completion by the end of January 2003. This will cause a delay of the same length to the project while HDSC waits for the data. The Big Island will be digitized first and should be completed by the end of the August 2002. The entry of the remaining islands will immediately follow. These delays are reflected in the projected schedules. During the next quarter the University will continue to hand enter data for the Big Island and probably begin hand entry for Maui County. The projected schedule is summarized in Table 3.

Table 3. Projected Schedule of Hand Entry of State Daily Gage Monthly Maximums.

| Island | Projected Completion Date |
|---|---|
| Big Island | 8/25/02 |
| Maui County (Maui, Lanai, Molokai) | 9/26/02 |
| Oahu | 10/25/02 |
| Kauai | 1/25/03 |

## 6.3 Spatial Relations (Depth Area Duration Study)

The method to be used for computing the DAD curves has been selected. Software to decode and format the data files and the DAD computations will be developed. During the next quarter we will also examine potential networks for the Hawaiian Islands.

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